Overview of ISECG Work: Expanding the Definition of the Lunar Exploration Scenario

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April 10th, 2014

ISECG Mission Scenario

Low-Earth Orbit

2020

2030

International Space Station

Commercial or Government-Owned Platforms

- Robotic Mission
- Human Mission
- Cargo Mission

Beyond Low-Earth Orbit

Test Missions

Near-Earth Objects

Rosetta

Hayabusa-2 (Sample Return)

OSIRIS-REx (Sample Return)

Asteroid Redirection

Apophis

Explore Near Earth Asteroid

Lunar Vicinity

Extended Duration Crew Missions

Staging Post for Crew to Lunar Surface

Potential Commercial Opportunities

Moon

LADEE

Luna 25

Chandrayaan-2

Luna 26

Luna 27

RESOLVE

SELENE-2

Luna 28/29 (Sample Return)

SELENE-3

Human-Assisted Sample Return

Humans to Lunar Surface

Potential Commercial Opportunities

Mars

MAVEN

ISRO Mars Orbiter Mission

ExoMars 2016

InSight

ExoMars 2018

Mars 2020

JAXA Mars Precursor

Human-Assisted Sample Return

Mars Sample Return Mission Opportunities

Human Scale EDL Test Mission Opportunities

Sustainable Human Missions to the Mars System

Multi-Destination Transportation Capabilities

(Planned and Conceptual)

Orion & SLS

Russian Piloted System

Advanced Electric Propulsion

Evolvable Deep Space Habitat

Orion & SLS (Upgrade)

Initial Cargo Delivery

Small Cargo Lander

Human Surface Mobility

Crewed Lunar Lander

Orion & SLS (Upgrade)

Icon indicates first use opportunity.
Commercial/Institutional launchers not shown.

Revisiting Approach to Lunar Exploration Scenario

Two parts to lunar surface scenario expansion activity:

① Update lunar lander transportation architecture

② Update surface strategy using reference surface Global Point of Departure (GPoD) architecture

Key Considerations

Human transportation options tend to drive overall cost of destination exploration. Multiple architectural mission options are being evaluated to characterize and score based on key Figures of Merit such as:

- Cost
- Performance (Capabilities and Mission Objectives Satisfaction)
- Technology Development
- Extensibility
- Mission Risk

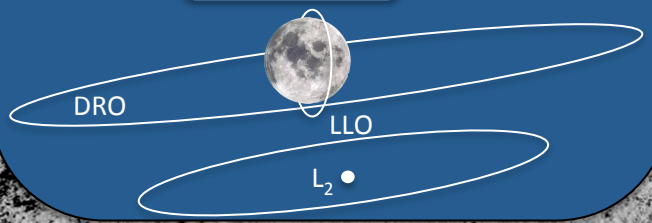
Updated approach to surface activities will be informed and developed based on down select of most attractive transportation architecture options. More to come in later GER workshops in Japan (July) and Europe (Oct) this year.

Lunar Surface Access Trade Space

The lunar surface trade space is divided between transportation options and lander properties within the context of utilizing an evolvable deep space habitat as a staging post.

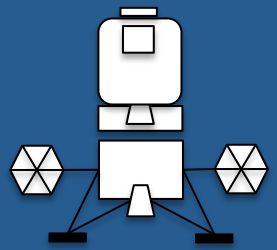
Transportation Options

eDSH Staging Location	Launch Vehicle	Lunar Orbit Insertion (LOI) Options
DRO	NASA SLS LV (Block 1B)	LOI by Lander
E-M L1/ L2	ESA LV	LOI by LV
HLO	JAXA LV	LOI → 0 (Long Transfer)
LLO	Roscosmos LV	SEP Used for Long Transfer
	Commercial Launch Vehicles	



Lander Properties

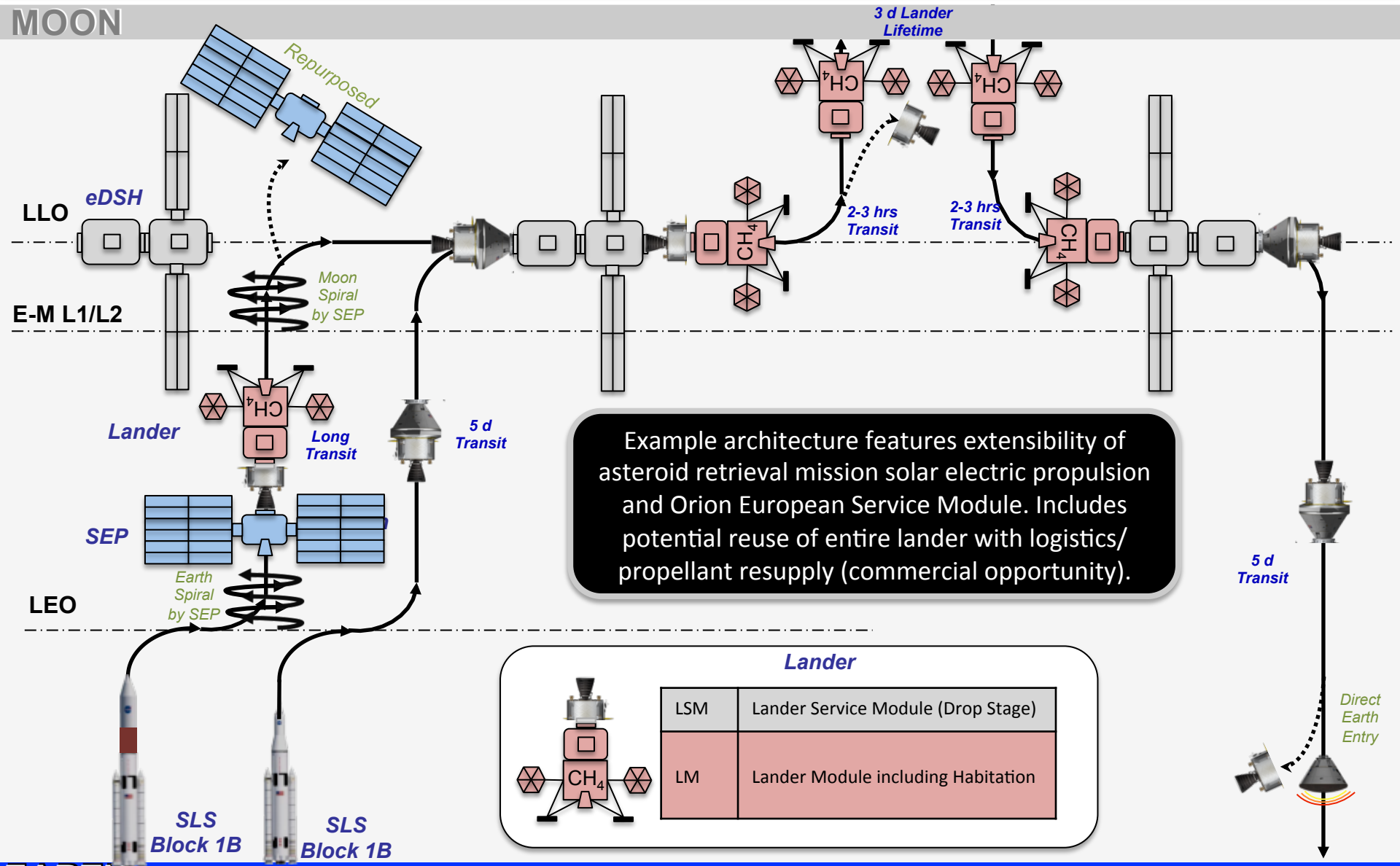
Lander Stage In-Space Propulsion	Lander Drop Stage Options	Reusability	Crew Size (to surface / on orbit)	Lander Hab. (days)
Hypergols	With Hypergolic Drop Stage	None	2/2	0
LOX/CH_4	With Evolved Hyper. Drop Stage	Crew Module	3/1	3
LOX/LH_2	Without Drop Stage / 2-Stage	Crew Md. & Refuel AM	4/0	7
		Crew Mod. AM & DM		



The trade space can be tailored by the international partners to meet a variety of core objectives and used to identify scenarios from which a viable human lunar campaign is achievable.

Example Architecture for Extensibility Lander

LLO Staging Location



Example architecture features extensibility of asteroid retrieval mission solar electric propulsion and Orion European Service Module. Includes potential reuse of entire lander with logistics/ propellant resupply (commercial opportunity).

Lander

LSM	Lander Service Module (Drop Stage)
LM	Lander Module including Habitation